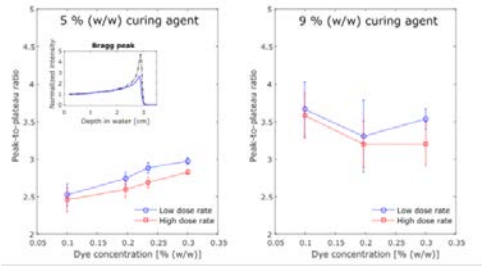
Material/methods: Dosimeters (1 x 1 x 4.5 cm^3) of varying chemical compositions were produced. They contained leuco-malachite green (LMG) dye as the active component, chloroform and silicone elastomer.
Twelve different batches were irradiated with 60 MeV proton beams, using a 40 mm circular collimator, to different doses (0 – 30 Gy). Irradiations were performed with both a low and a high dose rate (0.23 and 0.55 Gy/s). For comparison, depth–dose distributions were measured in water with a Markus-type, plane-parallel ionization chamber. Simultaneously, dosimeters from the same batches were irradiated with 6 MV photon beams in a 10 cm square field on a linear accelerator.
All dosimeters were read out before irradiation and four hours after, at a wavelength of 635 nm. The read-out was performed with a home-built 1D-scanner with a depth resolution of 0.2 mm for the proton irradiated dosimeters, while a spectrophotometer was used for the photon read-out. The dose-rate dependency was compared for proton and photon irradiations. The ratio of Bragg-peak to plateau response (at 1 cm) was compared between batches.
Results: The effect of lowering the dose rate was similar for proton and photon beams, although the beam qualities were different. The dose response was higher at a low dose rate, but at increasing dye concentration the effect was reduced.
Significant under-response was observed in the Bragg peak. The peak-to-plateau ratio was improved from (2.5 ± 0.1) to (3.0 ± 0.04) by increasing the dye concentration from 0.1 to 0.3 % (w/w). By increasing the curing-agent concentration from 5 to 9 % (w/w), the ratio further improved to (3.7 ± 0.4) and (3.5 ± 0.1) for the same respective dye concentrations.
Conclusion: The 3D radiochromic silicone based dosimeter has for the first time been investigated in proton beams, and it was demonstrated that chemical modifications could influence the dosimeter response.



The peak-to-plateau ratio measured for dosimeters containing different dye concentrations. All dosimeters contained 1.5 % (w/w) chloroform, while the curing agent concentration was 5 % (w/w) in the figure to the left and 9 % (w/w) in the figure to the right. The measurements have been separated into low dose rate (blue circles) and high dose rate (red squares). The ionization chamber showed a peak-to-plateau ratio of 4.82 ± 0.01. The inset shows one example of a measured proton depth–dose profile (blue full line), which has been normalized to the ionization chamber measurement (black dashed line) at a depth of 13.1 mm. The example given here is from a batch irradiated with protons at 0.23 Gy/s, where the dosimeters contained 0.23 % (w/w) dye, 1.5 % (w/w) chloroform and 5.0 % (w/w) curing agent.

Keywords: 3D dosimetry, proton therapy, quenching

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Accelerated Prompt Gamma estimation for clinical Proton Therapy simulations
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Purpose: There is interest in the particle therapy community to use prompt gammas (PG), a natural byproduct of particle treatment, for range verification and eventually dose control (Knopf *et al.* 2015). However, PG production is a rare process and therefore estimating PGs exiting a patient during a proton treatment plan executed by a Monte-Carlo simulation converges slowly. Recently, different approaches to accelerating the estimation of PG yield have been presented. Sterpin *et al.* (2015) described an analytic method that is about to be implemented in a commercial product, but has as drawback sensitivity to heterogeneities. Kanawati *et al.* (2015) described a variance reduction method (pgTLE) that accelerates the PG estimation by precomputing PG production probabilities as a function of energy and target materials, but has as drawback that it only works for analytical phantoms.
Materials/Methods: We present a two-stage method, voxellized pgTLE (vpgTLE) that extends pgTLE to voxellized volumes. PG production probabilities are precomputed once, stored, and reused. In stage one, we simulate the interactions between the treatment plan and the patient CT with low statistic MC to obtain the spatial and spectral distribution of the PGs. As primary particles are propagated throughout the patient CT, the PG yields are computed in each voxel from the initial database, as function of the current energy of the primary, the material in the voxel and the step length. The result is a voxellized PG yield image, normalized to a single primary. The second stage uses the intermediate PG image as a source to generate and propagate PGs throughout the rest of the scene geometry, e.g. into a detection device, proportional to the number of primaries desired.
Results: We have achieved a global speed-up of around 10^3 for a heterogeneous phantom, for a 2% relative uncertainty on the PG yield. The method agrees with a reference Monte Carlo simulation to within 1% at the level of 2% relative uncertainty on the PG. Preliminary work on a full simulation of a clinical spot-scanning treatment plan and a patient CT image indicates a similar gain factor. Gains per voxel range from 10^2 to 10^5.
Conclusion: We presented a generic PG yield estimator, drop-in usable with any geometry and beam configuration. We showed a gain of around three orders of magnitude compared to analog MC. With a large number of voxels and materials, memory consumption may be a concern and we will discuss the consequence and possible trade-offs. The method will be available in the next release of Gate.

Keywords: variance reduction, track length estimator, Monte Carlo simulation, clinical proton therapy, particle therapy, proton therapy, hadron therapy, vpgTLE

References:
[1] Knopf *et al.* (2015) Phys. Med. Biol.
[2] Kanawati *et al.* (2015) Phys. Med. Biol.
[3] Sterpin *et al.* (2015) Phys. Med. Biol.

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Correlation of Gross Tumour Volume and metabolic Tumour Volume for non-small cell lung cancer patients
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Metabolic Tumour Volume (MTV) is defined as the volume on FDG-PET/CT with increased FDG uptake. MTV has been shown to be of superior prognostic value compared to SUVmax in NSCLC. This study aims to explore the spatial overlap between CT-derived Gross Tumour Volume (GTV) and FDG-PET/CT derived MTV. The second aim was to investigate the impact of this overlap on progression-free survival (PFS) and overall survival (OS).
This was a single institution review performed in South Western Sydney, Australia. Inclusion criteria included proven NSCLC, stage I-III disease, radical radiotherapy and received PET imaging no more than 105 days before Tx. All FDG-PET